# ORAL SESSION: Higher Cognitive Functions: Mental representations and Imagery

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Oral Sessions

## Presentations

### Decoding Identity from Brain Activity elicited during the Recollection of Personal Experiences

Almost everyone can imagine themselves at a wedding, however each person does so differently because they have been to different weddings and have memories that no one else has. Our personal history of autobiographical memories contributes to defining us as individuals and in extreme cases, memories of traumatic events can profoundly affect our psychological health and quality of life. A principal goal of cognitive science is to understand how and where such memories are represented in the human brain. Whilst functional Magnetic Resonance Imaging (fMRI) studies have identified anatomical regions that are activated during imagination of different scenarios[1,2], it is currently unclear whether activation differences between pairs of individuals represent anything more than functionally-irrelevant between-subject noise. We here hypothesize that fMRI activity patterns elicited as individuals imagine weddings, funerals and other scenarios reflect their own personal experiences, and test this by devising models of personal experience that discern participant identity from fMRI.

#### Presenter

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### Real-time reconstruction of letter shapes in the Mind's Eye

In previous work (Sorger et al., 2012), we developed the first fMRI-based letter speller brain-computer interface (BCI) allowing robust communication. Decoding of words on a letter by letter basis without motor acts was established via an encoding scheme of three conceptually distinct mental tasks at different moments in time. This is challenging for participants as it does not offer a meaningful connection between the intended letter and the specific content of mental imagery. In an effort to provide a more natural letter-speller system, we recently developed a procedure to reconstruct vividly imagined letter shapes from associated activity patterns in early visual areas measured with 7 Tesla fMRI (Senden et al., 2019). Reconstruction of a stimulus from brain activity patterns requires only a short (10 minutes) scan for estimating population receptive fields (pRFs) in early visual cortex. Reconstructions of ongoing imagery can then be achieved by projecting cortical activations back into the visual field. Note that signals in early visual cortex in response to imagery are weaker compared to visually presented stimuli, lowering the signal to noise ratio. This renders reconstructed letter shapes of mental imagery less clear than those reconstructed from perceived letters. To overcome this issue, we utilized an autoencoder neural network to nevertheless obtain visually recognizable reconstructions at the single trial level. In the present study, we build on these technological advancements and aim to efficiently implement pRF mapping tools as well as reconstruction procedures for real-time fMRI, and demonstrate the feasibility of a "MindsEyeBCI" by reconstructing and classifying imagined letter shapes (H, T, S, C) in real-time.

### Presenter

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## Neural Tracking of Rhythmic Constructs in Imagined Speech

Speech mental imagery is the quasi-perceptual experience and requires top-down regulation of memory retrieval in which phonological, lexical and semantic details of speech were rapidly organized and internally represented. The neural dynamics underlying speech mental imagery keeps mysterious due to the challenge to directly capture imagery-related neural activates without external signals. Recently, novel metrics for tagging the rhythms of phrases and sentences during speech comprehension have been developed (Ding et al., 2016; Sheng et al., 2019) and has thus far tested in perceived speech when the bottom-up speech input were concurrently parsed into hierarchically-organized structures. Taking advantage of the frequency-tagging paradigm, here we investigated, for the first time, the neural representations of the higher-order rhythmic constructs formed in imagined speech when only internal speech were generated in mind.

### Presenter

*Lingxi Lu*, Peking University Beijing, Beijing
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## Content-Specific Neural Patterns in Auditory Cortices During Imagery of Music

As part of their mental world, humans are able to internally represent ongoing auditory information without a direct external stimulus. Auditory imagery, the internal representation of sounds, has been mostly studied by looking for spatially overlapping neural responses while listening versus internally recalling sounds (Zatorre et al., 1996; Halpern 2001; Herholz et al., 2012). However, that approach does not allow a distinction between general mechanisms of imagery as opposed to representation of specific imagined content. In the present work, we venture beyond basic spatial localization of averaged signals by comparing the unique temporal response profile of heard and imagined complex and continuous sounds, and explore the influence of rhythmic motion on the internal auditory replay.

### Presenter

*Mor Regev*, Montreal Neurological Institute Montreal, QC
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## Individual Differences in Shared Representation of Symbolic and Nonsymbolic Number at 7T fMRI

There is currently no consensus view on whether the encoding of symbolic number is grounded in the nonsymbolic neural system [1], is developmentally independent [2], or is linked at one point but then decoupled over developmental time [3]. However, it is well-documented that fluency of perceiving both formats, and translating between them, is associated with math skills across the life span [4–6]. To understand these phenomena, and their effect on math learning, the current study addresses three essential questions. First, do symbolic and nonsymbolic representations of number share cortical patterns of activation? Second, are representations of number task-dependent? Third, do patterns of neural response to number (i.e. decoding performance and between-format generalization) relate to behavioral metrics of numerical ability, measured by (a) number comparison tasks in both number formats, and (b) a standardized mathematics achievement measure.

### Presenter

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## Brain structure and function predict different domains of cognitive control in normal aging

Cognitive control refers to the mechanisms involved in the flexible allocation of mental resources during goal-directed behavior and comprises three correlated but distinct domains--inhibition, shifting, and working memory (Miyake et al., 2000; Miyake & Friedman, 2012). Normal aging is characterized by declines in cognitive control, which have been attributed to both structural and functional alterations in prefrontal and parietal cortices (Raz & Rodrigue, 2006; Spreng et al., 2010). However, the specific contributions of brain structure and function to individual and age differences in performance on each domain are not well understood.

## Presenter

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